

Bluetooth® Heart Rate Monitors for Spaceflight

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Heart rate monitoring is required during exercise for crewmembers aboard the International Space Station (ISS) and will be for future exploration missions. The cardiovascular system must be sufficiently stressed throughout a mission to maintain the ability to perform nominal and contingency/emergency tasks. High quality heart rate data is required to accurately determine the intensity of exercise performed by the crewmembers and show maintenance of VO_2max . The quality of the data collected on ISS is subject to multiple limitations and is insufficient to meet current requirements. **PURPOSE:** To evaluate the performance of commercially available Bluetooth® heart rate monitors (BT_HRM) and their ability to provide high quality heart rate data to monitor crew health on board ISS and during future exploration missions. **METHODS:** Nineteen subjects completed 30 data collection sessions of various intensities on the treadmill and/or cycle. Subjects wore several BT_HRM technologies for each testing session. One electrode-based chest strap (CS) was worn, while one or more optical sensors (OS) was worn. Subjects were instrumented with a 12-lead ECG to compare the heart rate data from the Bluetooth sensors. Each BT_HRM data set was time matched to the ECG data and a $\pm 5\text{bpm}$ threshold was applied to the difference between the two data sets. Percent error was calculated based on the number of data points outside the threshold and the total number of data points. **RESULTS:** The electrode-based chest straps performed better than the optical sensors. The best performing CS was CS1 (1.6%error), followed by CS4 (3.3%error), CS3 (6.4%error), and CS2 (9.2%error). The OS resulted in 10.4% error for OS1 and 14.9% error for OS2. **CONCLUSIONS:** The highest quality data came from CS1, unfortunately it has been discontinued by the manufacturer. The optical sensors have not been ruled out for use, but more investigation is needed to determine how to get the best quality data. CS2 will be used in an ISS Bluetooth validation study, because it simultaneously transmits Magnetic Pulse which is integrated with existing exercise hardware on ISS. The simultaneous data streams allow for beat to beat comparison between the current ISS standard and CS2. Upon Bluetooth® validation aboard ISS, down select of a new BT_HRM for operational use will be made.